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Office of Space Sciences and Applications, Code SC
National Aeronautics and Space Administration
Washington, D. C. 20546

Subject: Status Report on NASA Research Grant NsG-258

Title: Submillimeter Interference Spectrometer

Gentlemen:

This letter reports the status of research on the subject grant for the period 1 May to 31 October 1965. Progress prior to this period was reported in a letter dated 12 May 1965.

The subject grant concerns research for the development of a submillimeter spectrometer facility. During the reporting period research effort was directed toward investigation of the measurement of dielectric properties of materials by observing the transmission loss as a function of frequency, the preparation of an operation manual for the instrument, and installation, checkout and use of the helium-cooled germanium bolometer recently acquired on the grant.

The potential of the interference spectrometer as a tool for the measurement of dielectric properties of solids was explored. The method used was to insert a thick dielectric sample in the source beam and to record interferograms with the sample in place and removed. The difference of these interferograms is used to obtain a spectrum of the energy lost by insertion of the dielectric. Because samples chosen are a few wavelengths thick one would expect to see a cyclic spectrum caused by interference reflection between the two surfaces of the sample. Knowledge of the amplitude and frequency separation of these spectrum ripples can be used to estimate the dielectric constant and loss tangent of the material. Experiments were performed using the low pressure neon plasma noise source and evacuated barretter in the frequency range of 45 to 75 GHz on materials having dielectric constants from 2.2 to 8. It was found that the transmission loss method is severely limited by system dynamic range for the smaller dielectric constants and loss tangents, but that satisfactory measurements should be possible for large values of these quantities. The transmission loss method is felt not to be effective because it requires a moderately high spectral resolution for reasonable sample thickness. What is needed is a measurement method which takes advantage of the relatively broadband nature of most materials and has improved sensitivity for low values of dielectric constant and loss tangent. It is felt that the availability of such

a technique would make possible a program of dielectric measurements of considerable value to the field of millimeter and submillimeter technology. Although it is not possible to pursue this investigation further on the subject grant, it is planned to seek financial support to continue the effort.

An operating handbook has been drafted for the spectrometer. This handbook prescribes alignment procedures for the optical system and choices of sources and detectors, relates mirror motion and total recording time to spectral resolution and output signal-to-noise ratio, prescribes suitable sampling intervals and choice of integrating time constant, describes procedures for locating the zero point of the interferograms and for handling the data in computer processing, and guides in the choice of a suitable apodizing function.

The helium-cooled germanium bolometer was received during the reporting period. The bolometer was installed in the spectrometer, a radiation coupler incorporating a thermal gap and vacuum window was fabricated and fitted to the detector, and the necessary biasing circuitry and preamplifier constructed. During the period of checkout when experience was being gained in the handling of liquid helium and in the cryogenic and electric behavior of the detector, one of the support wires of the germanium flake broke. The reason for the failure was not found, but the bolometer has since been repaired by the manufacturer.

The bolometer has been used with the interference spectrometer to obtain instrument spectra over the frequency region from 200 to 1200 GHz. In these spectra are found the strong water absorption lines at 550, 750, and 980 GHz and the strong complex of lines around 1100 GHz. The absorption sample involved here was moderately humid room air in the 2-meter path length of the interferometer. Because of the physical bulk and mounting location of the bolometer the spectrometer tank lid cannot be lowered into place for evacuation. When this lid is modified the tank will be pumped out, and spectra with and without the presence of atmospheric water vapor can be compared to yield a true H_2O absorption spectrum and an accurate evacuated instrument spectral function. At present, the useful upper frequency limit of the instrument has not been determined because of the large water vapor absorption above 1000 GHz.

A great amount of useful but sometimes frustrating experience has been obtained with the cryogenic bolometer and its use with the spectrometer. In spite of this, many factors in its operation have not yet been determined. Among those measurements which have been temporarily bypassed are ones concerning the bolometer NEP and excess noise, preamplifier excess noise, stability of the noise source, the dynamic range of the detector output and data recording system and the determination of minimum detectable absorption strength. Priority of investigation has so far been placed on the instrument spectral function, but it is expected that many of these other factors will be known soon.

Program for 1 November 1965 through 31 January 1966

Because of the delay incurred by the necessary repair of the bolometer, application was made to NASA and permission granted to extend the termination

date of the grant to 31 January 1966. During this period the vacuum system modification will be completed to accomodate the cryogenic bolometer. The spectrometer will be then used to determine which rotational transitions of water vapor other than the ones already identified at 550, 750, 980, and 1100 GHz are observable in the two meter path within the instrument. The evacuated chamber will also be used to ascertain the minimum transmission loss of the system as well as to examine how the instrument spectral function falls off with increasing frequency (with negligible water vapor present). A report describing the facility and a documentation of the research involved in its development will be prepared.

Respectfully submitted,

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Approved:

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